7/90
15-1
16792

How to Plan the Lighting Installation for a Factory

TD CAT 1919 General Electric Co.
Natl. Lamp Works
ATHENAEUM OF PHILADELPHIA

P. Mass 9/20

How to Plan the Lighting Installation for a Factory

A Hand Book for Lighting Equipment Distributors, Electrical Contractors, Central Station and Other Lighting Salesmen

September First
Nineteen-Nineteen

NATIONAL LAMP WORKS
of General Electric Co.
NELA PARK :: CLEVELAND, OHIO

FOREWORD

THE purpose of this booklet is to give simple rules for the installation of MAZDA C lamps in industrial plants. The data included apply to the three principal types of lighting units which, in such locations, are well adapted for use with MAZDA C lamps, namely:

1. RLM Dome with bowl-frosted lamp or RLM Dome with lamp equipped with opal cap.
2. Reflecto-cap Diffuser.
3. Semi-enclosing units, i. e., units which consist essentially of a bowl of diffusing glass suspended beneath an upper reflector of opal glass, porcelain-enameled steel, or plaster of Paris.

These types are discussed on pages 35 and 36. Study these pages carefully before attempting to use the subsequent data, in order to determine to which type any lighting unit belongs.

This booklet contains only the essential information necessary to plan an installation of factory lighting. For the sake of brevity no attempt has been made in these pages to explain the reasons for the various steps in calculating the proper sizes of lamps to use, spacing, mounting, height, etc. More detailed information will be found in Engineering Department Bulletins No. 20A, *Industrial Lighting*, and No. 7C, *Fundamentals of Illumination Design*, which may be obtained on request.

#246890208 Td Cat
6-14-2004
11-6-91 1919 General...

Amount of Light Required

THE first step in planning an installation is to determine how much light will be required. The illumination to be supplied in any given case will, of course, depend upon the purpose for which the light is used. Industries requiring close work on the part of the employee need a higher intensity of illumination than those in which a coarser grade of work is done. For instance, fine machine operations require more light than foundries. These requirements have been considered in the Classification Table beginning on page 21. A factory classified as Grade 3 requires more wattage per square foot than one designated as Grade 2 and so on. The class or grade number corresponds approximately to the foot-candle intensity required as determined through actual experience in the lighting of various industries.

Requirements of Good Factory Lighting

The four fundamental requirements of any satisfactory industrial lighting installation are:

1. Sufficient light on all parts of the working areas.
2. Moderate light on adjacent areas and on the walls.
3. Freedom from glare and glaring reflections.
4. A system which is simple, reliable, easy to maintain and of low operating cost.

Two Classes of Installations

In planning any industrial lighting installation, one of the two following conditions is presented:

1. Where the building has not been wired previously, or where, if wired, the customer is willing to rearrange outlets, if necessary, to secure adequate illumination. Here the greatest freedom is allowed in planning the installation, which latitude permits thoroughly satisfactory lighting results.

2. Where no change or addition is to be made in existing outlets. In this case one has but to decide upon the proper type and size of unit to replace the present fixtures. The advantage to be gained by changing over is then dependent entirely upon the greater efficiency and diffusion of light furnished by the newer units in comparison with less modern equipment.

Case I—The Planning of Illumination for New Plants or in Old Plants Where Existing Outlets Need Not be Utilized.

(a) Choose the type of lighting unit best adapted to the location, with due regard to the several suggestions given on pages 35 and 36.

(b) Measure the ceiling height of the room and decide upon the greatest practical mounting height of the lighting units.

In case the mounting may be close to the ceiling, approximately one foot must be allowed as the minimum mountable distance between the ceiling and the center of the lamp filament, as shown in the illustration adjoining.

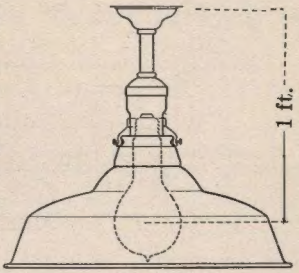


Fig. 1

(c) Refer to the Spacing-Mounting Height Table, page 20, corresponding to the unit selected, and find what the average distance between units should be that will correspond to the mounting height determined upon.

(d) Make a diagram to scale of the floor area of the room to be lighted and lay out on it the position of lamp outlets. If the width of the room is not much greater (from 2 to 5 feet) than the spacing value just found, one row of outlets down the center will be sufficient. Otherwise, the outlets should be laid out in two or more rows in the form of squares, or approximately so (see Fig. 2, page 6), the distance between units being approximately the spacing distance found in (c). The distance between the outside row of units and walls

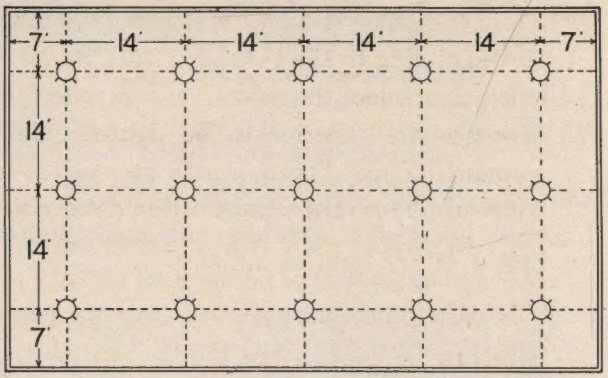


Fig. 2

Showing how lighting outlets should be laid out to provide a practical degree of uniformity in light distribution. Here each lighting unit is given a definite area to illuminate, i. e., all the space falling within 7 feet from a point directly beneath the lighting unit. As a matter of fact, however, there is an over-lapping of light; each unit furnishes more or less light on every point lighted depending upon its distance.

should not be greater than one-half the spacing distance (see Fig. 2 above). For offices it should be one-third the spacing distance.

(e) Compute the total floor area of the room by multiplying its length in feet by its width in feet (making due allowance for irregularities in contour).

(f) Divide the area thus found by the number of outlets. This will give the average number of square feet which each unit must illuminate.

(g) Find from the Classification Table, pages 21 to 27 inclusive, the class to which the lighting installation belongs.

(h) From the Table showing Watts per Square Foot corresponding to the type of fixture under consideration, select the column which most nearly describes the interior to be lighted. In this column find the figure (watts per square foot) which applies to the Classification determined in (g). Multiply this value of watts per square foot by the area to be illuminated by each lamp. The result will indicate the size in watts of lamps to be used.

Thus the problem is solved, as size of lamps, type of fixture, mounting height and spacing have been determined.

In some factory rooms only one kind of work is done. In this case it is simple enough to find from the tables the proper value of "watts per square foot." Obviously the correct system of illumination will be a general lighting installation of equally spaced lighting units at equal mounting heights, to provide the proper light intensity.

Where two or more manufacturing processes are carried on in the same room, it is desirable to light the entire area to the highest intensity required by any of the processes, or to plan the installation on this basis and then perhaps to use smaller lamps in the outlets well removed from locations where the higher intensity is required.

Case II—Planning an Installation Where Existing Outlets Must be Utilized

Here, in addition to choosing the type of fixture to be employed as in (a), page 5, it is only necessary to decide upon the size of lamp and the mounting height of the units. Items b, c and d, as determined in Case I, page 5, need not here be calculated.

(e) Compute the total floor area of the room to be lighted by multiplying the length in feet by the breadth in feet (making due allowance for irregularities in contour).

(f) Divide the area in square feet thus found by the number of outlets. This will give the average number of square feet which each unit must illuminate.

(g) Find from the Classification Table, pages 21 to 27 inclusive, the class to which the lighting installation belongs.

(h) From the Table showing Watts per Square Foot corresponding to the type of fixtures under consideration, select the column which most nearly describes the interior to be lighted. In this column find the figure (watts per square foot), which applies to the classification determined in (g). Multiply this value of watts per square foot by the area to be illuminated by each lamp. The result will indicate the size in watts of lamps to be used.

(i) It now only remains to determine the proper mounting height of the units. When there is only one row of units take the distance (A) between two units (see Fig. 3, page 10, or the width (B) of the store, if this value is larger than (A), and from the Spacing—Mounting Height Table given on page 20 find the best mounting height for this spacing. The width of the room is considered the same as the distance between two units. If there are more than one row of units, determine the best mounting height, using the larger of the two spacing values, A or A′ (see Fig. 3, page 10). If, as is sometimes the case, the ceiling is not quite high enough to permit this mounting height, place the units as close to the ceiling as possible. But when the discrepancy between the mounting height indicated by the Table, and the greatest height which the ceiling permits, is large, the number of outlets in the room is not sufficient to make possible a lighting installation which will give uniform and satisfactory light with any kind of lighting fixture. The customer should be urged to re-wire. If this is done, the lighting layout must then be recalculated on the basis of figuring outlined under the Planning of Illumination for New Plants or in Old Plants where Existing Outlets Need Not Be Utilized, page 5.

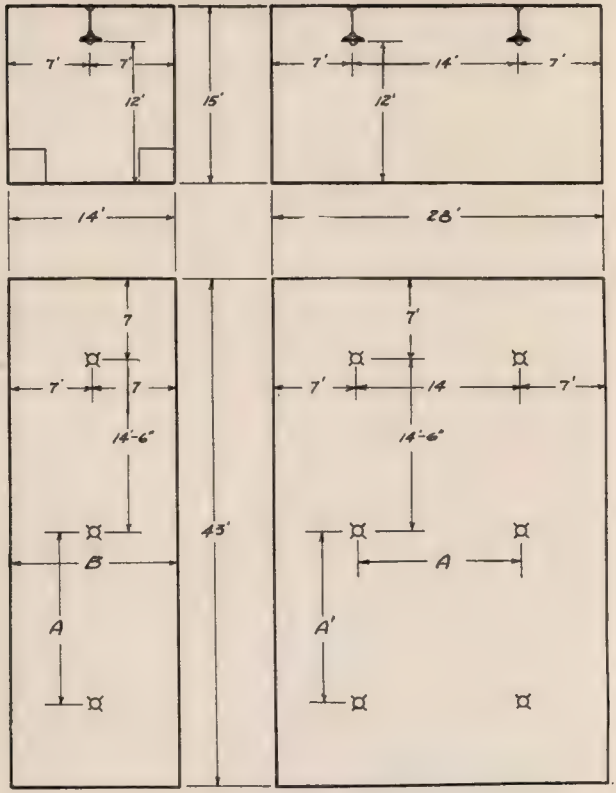


Fig. 3

To the left is shown the ground plan and an end elevation of a long narrow work room, while to the right we have a room of the same length and height but of twice the width. It will be noted that in both cases each lighting unit is given an area to light of 7 feet radius. In long narrow rooms when one row of outlets is sufficient, the width of the room should be taken as the spacing figure if it is greater than the actual distance between the outlets. When there are two or more rows of outlets the ideal arrangement is that of squares though rectangles are satisfactory if the difference between the length and breadth of the rectangle in any given case is not too marked.

Frequently it may be hard to decide between specifying one or two rows of lighting units, or, the installation may so figure out that one is undecided as to whether, for example, 100 or 150-watt lamps should be used. In such cases one must depend upon his best judgment and experience in arriving at the correct solution.

For some classes of work absolutely uniform illumination is not necessary, and the spacing ratio may be stretched a little where there is a considerable advantage to be gained by so doing. On the other hand, in places where uniform illumination is a prime requirement, and when there is any doubt as to whether one row of units or two should be used, always install two.

Likewise, in deciding between two sizes of lamps, if it is felt that the location is one in which especially good lighting will not be appreciated, one may be justified in choosing the smaller of the two. In the end, however, the customer will usually be better satisfied with an ample intensity of light even though the first cost of installation and the current consumption may be a little higher.

Recommendations should in nearly all cases be based on the highest lighting intensity classification as shown in Classification Tables. The better illumination which results is easily worth the slight increase in initial cost and upkeep.

The trend of industrial lighting progress is continually towards higher intensities as industrial executives more generally realize the stimulative effect of good illumination on manufacturing production. You are therefore justified in basing your calculations on the highest intensities shown in the Classification Tables wherever the purchaser can be made to appreciate that the slightly increased lighting cost is a worth-while investment.

Example No. 1.

Lay out a general lighting system for a new machine shop where considerable medium grade bench work is to be done. The shop is 100 feet x 120 feet, and is 11½ feet high. Lengthwise steel trusses divide the ceiling into six sections or bays, each 100 feet long. Crosswise there are four bays, each 25 feet across. Thus there are in all 24 sections or bays, each 20 feet by 25 feet. (See Figure 4, page 13.) The ceiling and walls are light colored. The management, let us assume, is willing to install especially good lighting.

(a) In this particular shop the character of the work is such that there are not likely to be objectionable reflections from polished or oily surfaces, therefore RLM Dome reflectors with bowl-frosted MAZDA C lamps will give satisfaction.

(b) Since the ceiling height is 11 feet 6 inches the mounting height of the units above the floor will probably not be more than 10 feet 6 inches. This figure is therefore set as a tentative mounting height.

(c) Referring to the Spacing—Mounting Height table, page 20, it is found that for a mounting height of 10 feet 6 inches the outlets may be 13 feet apart.

(d) Figure 4, page 13, shows how to diagram the room to scale and locate the outlets. Four outlets per bay make a good uniform arrangement, therefore this arrangement will be specified although it brings the spacing distance a little closer than necessary. Twelve outlets therefore should be set in lengthwise and eight outlets crosswise, making a total of 96 outlets.

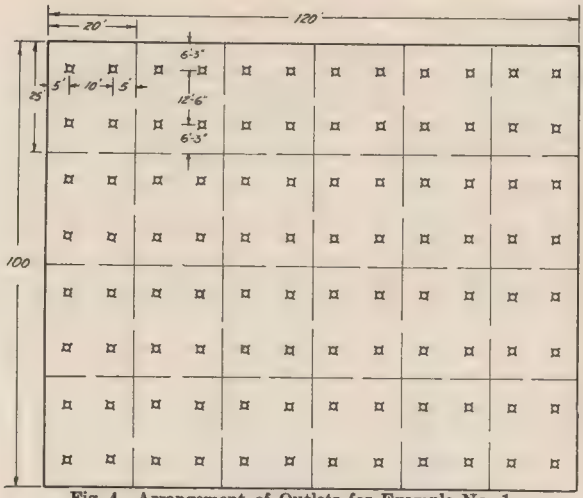


Fig. 4—Arrangement of Outlets for Example No. 1

(e) Area of floor is 100 x 120 or 12,000 square feet.

(f) Average number of square feet each unit must illuminate is $12000 \div 96 = 125$.

(g) Turning to the Classification Table, page 24, it is found that this machine shop falls in Class X, i.e., it requires a lighting intensity of 10 foot-candles, based on the assumption that especially good lighting is required and that the major operation in the plant is medium grade bench-work.

(h) Referring to the table; Watts per Square Foot for RLM Dome Reflectors with Bowl-Frosted Lamps, page 29, it is found that a room with light walls and ceiling, having more than one row of units, in Class VIII, requires 1.25 watts per square foot. $125 \times 1.25 = 156$, which figure represents the wattage of the lamps to be used. Since MAZDA C lamps are not made in 156-watt sizes, 150-watt lamps should be specified.

Thus the problem is solved and ninety-six 150-watt MAZDA C, bowl frosted lamps in Dome 150 RLM reflectors should be installed, located as in Figure 4, shown above.

Example No. 2.

It is desired to replace the present lighting system with up-to-date lamps and fixtures in an inspection room of a manufacturing plant. The inspection work may be termed as medium in requirement. This room requires illumination of good quality, without glare or shadows. The dimensions of the room are as follows: 70 feet long, 30 feet wide and 12½ feet high. The room has light walls and ceiling. The room is already equipped with two rows of outlets, five in each row; the spacing being 15 feet crosswise and 14 feet lengthwise; as shown in Figure 5 on this page.

The solution of the problem is in Case II, as outlined on page 8.

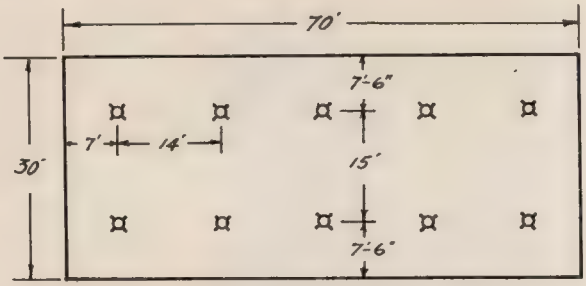


Fig. 5 — Arrangement of Outlets for Example No. 2

(a) Since glare and shadows are to be avoided the Reflecto-cap Diffuser would be the proper fixture to install.

(e) Area of floor is 70 feet × 30 feet or 2100 square feet.

(f) Number of square feet to be illuminated by each unit is 2100÷10=210.

(g) The Classification Table, page 23, indicates that this room should fall in Class X, i. e., requires a lighting intensity of 10 foot-candles, inasmuch as inspection work of medium grade is carried on and particularly good lighting is desired.

(h) Referring to the Table, Watts per Square Foot for Reflecto-cap Diffusers, page 32, it is found that a room with light walls and ceiling having more than one row of units, in Class 10, requires 1.80 watts per square foot.

$210 \times 1.80 = 378$. This figure indicates the wattage of lamps to be used. Therefore, ten MAZDA C, 400-watt lamps in the proper size of Reflecto-cap Diffuser units should be specified.

The Foot-Candle Meter

The foot-candle is the unit of illumination intensity. Direct measurements of foot-candle intensities may be made with a small portable instrument known as a foot-candle meter, illustrated on this page. The further use of this instrument is explained on page 17.

Figure 6
Front View

Figure 7
Back View with Case Open

The Foot-Candle Meter and Its Use

The foot-candle meter as illustrated in Figures 6 and 7, page 16, is a light, portable instrument with which one may determine the degree of intensity of illumination at any point.

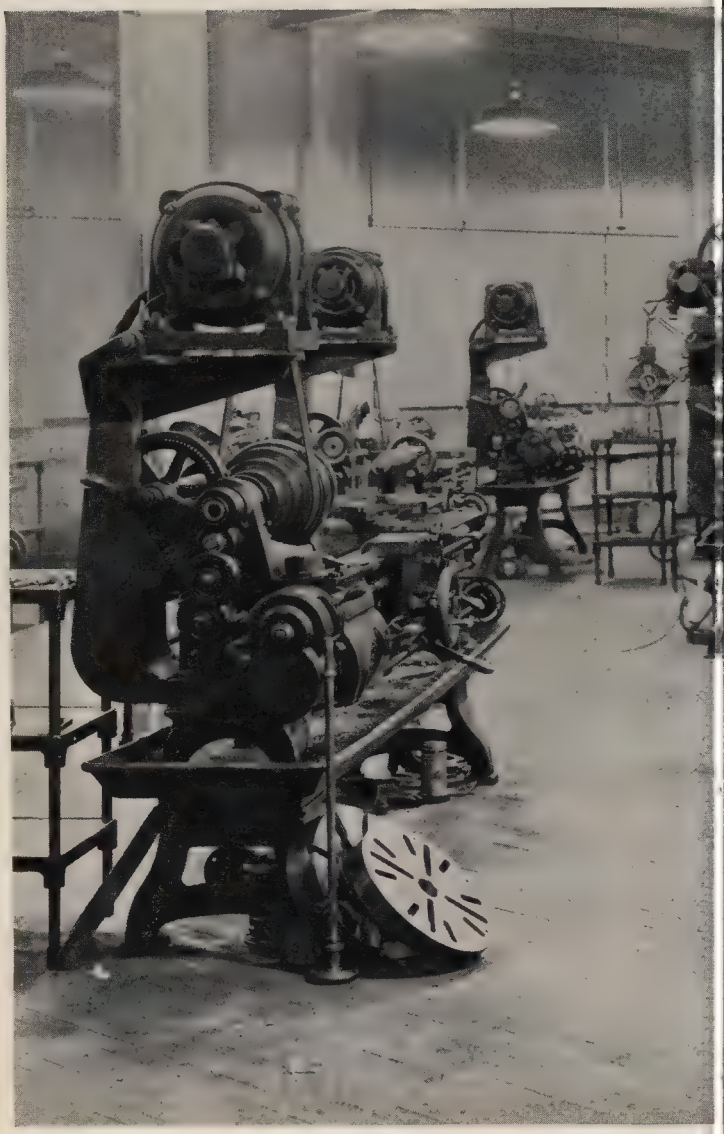
The foot-candle intensities as indicated by the meter for any room or bay in a factory may be checked against the foot-candle intensities or class as given in the Classification Tables on pages 21 to 27 inclusive. These show the illumination intensity which experience has proved to be needed for various classes of industry.

Thus through the foot-candle meter you have a direct test or means of knowing whether the lighting of a factory is or is not adequate.

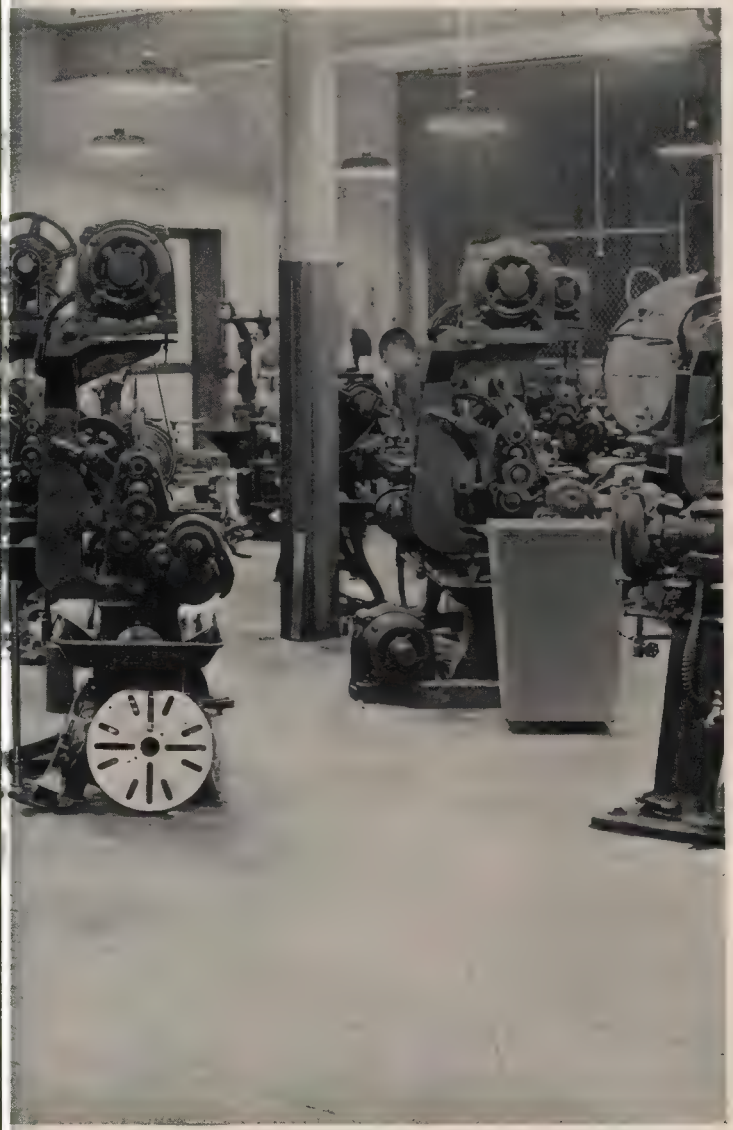
The foot-candle meter further enables you to know definitely whether the illumination is uniform. If light in a room is not evenly distributed, the indications of the meter at different points about the room will show this condition of uneven light distribution.

The foot-candle meter is simple in construction and is not easily damaged. Readings are made direct in foot-candles, so that no mathematical calculations are needed to make the readings significant.

The foot-candle meter with leather carrying case may be obtained through any Sales Division of the National Lamp Works or direct from the Engineering Department, Nela Park, Cleveland, Ohio. The price for each meter and case is $25.00 payable in advance.



Installation of Reflecto-cap Diffuser Units and MAZDA C Lan
photograph taken without other illumination



s in a machine shop. Illustration made from an un-retouched
n that supplied by the regular lighting installation.

SPACING-MOUNTING HEIGHT TABLE

RLM Dome and Reflecto-cap Units		Translucent, Diffusing Bowl Semi-enclosing Units	
Mounting Height of Unit Above Floor	Maximum Desirable Spacing Distance	Mounting Height of Unit Above Floor	Maximum Desirable Spacing Distance
Feet	Feet	Feet	Feet
8′6″	10′	9′	10′
9′	11′	10′	11′
9′6″	12′	10′6″	12′
10′6″	13′	11′	13′
11′	14′	12′	14′
11′6″	15′	12′6″	15′
12′	16′	13′	16′
12′6″	17′	14′	17′
13′6″	18′	14′6″	18′
14′	19′	15′	19′
14′6″	20′	16′	20′
15′	21′	16′6″	21′
15′6″	22′	17′	22′
16′6″	23′	18′	23′
17′	24′	18′6″	24′
17′6″	25′	19′	25′

CLASSIFICATION TABLES

The intensities of illumination by classes, as indicated in these tables, apply under all average conditions. There are some operations on dark or very fine materials, which require special provision for higher intensities than here indicated. These cases call for good judgment. Bear in mind that it is better to err on the side of more light than is actually necessary, than on the side of too little light.

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Aisles, Stairways, Passageways and Corridors	1	2
Assembling		
Rough	3	6
Medium	4	8
Fine	6	12
Bakeries	4	8
Boilers, Engine Rooms and Power Houses		
Boilers, Coal and Ash Handling, Storage Battery Rooms	2	4
Auxiliary Equipment, Oil Switches and Transformers, Switch Boards	3	6
Engines, Generators, Blowers, Compressors	4	8
Candy Making	4	8
Canning and Preserving	4	8
Chemical Works		
Hand Furnaces, Boiling Tanks, Stationary Driers, Stationary or Gravity Crystallizing	2	4
Mechanical Furnaces, Generators and Stills, Mechanical Driers, Evaporators, Filtration, Mechanical Crystallizing, Bleaching	3	6
Tanks for Cooking, Extractors, Percolators, Nitrators, Electrolytic Cells	4	8

*Note—The figures under the headings "Class" are foot-candle intensities.

CLASSIFICATION TABLE—Continued

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Clay Products and Cements		
Grinding, Filter Presses, Kiln Rooms	2	4
Molding, Pressing, Cleaning and Trimming	3	6
Enameling	4	8
Coloring and Glazing	6	12
Cloth Products		
Light Goods	6	12
Dark Goods	8	16
Dairy Products	4	8
Drafting	8	16
Electric Manufacturing		
Storage Battery, Molding of Grids	4	8
Coil and Armature Winding, Mica Working, Insulating Processes	6	12
Elevators, Freight and Passenger	3	6
Forge Shops and Welding		
Rough Forging	3	6
Fine Forging and Welding	5	10
Foundries		
Charging Floor, Tumbling, Cleaning, Pouring and Shaking Out	2	4
Rough Molding and Core Making	3	6
Fine Molding and Core Making	5	10
Glass Works		
Mix and Furnace Rooms, Casting and Lehr	3	6
Grinding, Glass Blowing Machines, Cutting Glass to Size, Silvering	4	8
Fine Grinding, Polishing, Beveling, Inspecting, Etching and Decorating	6	12

*Note—The figures under the headings "Class" are foot-candle intensities.

CLASSIFICATION TABLE—Continued

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Glove Manufacturing		
Light Goods		
Cutting, Pressing, Knitting	4	8
Sorting, Stitching, Trimming and Inspecting	6	12
Dark Goods		
Cutting, Pressing, Knitting	6	12
Sorting, Stitching, Trimming and Inspecting	8	16
Hat Manufacturing		
Dyeing, Stiffening, Braiding, Cleaning and Refining		
Light	3	6
Dark	5	10
Forming, Sizing, Pouncing, Flanging, Finishing, Ironing		
Light	4	8
Dark	6	12
Sewing		
Light	6	12
Dark	8	16
Ice Making	3	6
Engine and Compressor Room	4	8
Inspecting		
Rough	3	6
Medium	5	10
Fine	8	16
Jewelry and Watch Manufacturing	8	16
Laundries and Dry Cleaning	4	8
Leather Tanning		
Vats	2	4
Cleaning, Tanning and Stretching	3	6
Cutting, Fleshing and Stuffing	4	8
Finishing and Scarfing	6	12

*Note—The figures under the headings "Class" are foot-candle intensities.

CLASSIFICATION TABLE—Continued

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Leather Working		
Pressing and Winding		
Light	4	8
Dark	6	12
Grading, Matching, Cutting, Scarfing, Sewing		
Light	6	12
Dark	8	16
Locker Rooms	2	4
Machine Shops		
Rough Bench and Machine Work	3	6
Medium Bench and Machine Work, Ordinary Automatic Machines, Rough Grinding, Medium, Buffing and Polishing	5	10
Fine Bench and Machine Work, Fine Automatic Machines, Medium Grinding, Fine Buffing and Polishing	8	16
Meat Packing	4	8
Milling and Grain Foods		
Cleaning, Grinding or Rolling	3	6
Baking or Roasting	4	8
Offices	6	12
Packing	4	8
Paint Manufacturing	4	8
Paint Shops		
Dipping, Spraying, Firing	3	6
Rubbing, Ordinary Hand Painting and Finishing	4	8
Fine Hand Painting and Finishing	6	12
Extra Fine Hand Painting and Finishing (Automobile Bodies, Piano Cases, etc.)	8	16
Paper Box Manufacturing		
Light	3	6
Dark	5	10

*Note—The figures under the headings "Class" are foot-candle intensities.

CLASSIFICATION TABLE—Continued

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Paper Manufacturing		
Beaters, Machine, Grinding	3	6
Calendering	4	8
Finishing, Cutting and Trimming	6	12
Plating	3	6
Polishing and Burnishing	5	10
Printing Industries		
Matrixing and Casting, Miscellaneous Machines, Presses	4	8
Proof Reading, Lithographing, Electrotyping	6	12
Linotype, Monotype, Typesetting, Composing Stone, Engraving	8	16
Receiving and Shipping	3	6
Rubber Manufacturing and Products		
Compounding, Mills, Fabric Preparation, Stock Cutting, Tubing Machine, Solid Tire Operations, Mechanical Goods Building, All Vulcanizing	4	8
Calenders, Bead Building, Pneumatic Tire Building and Finishing, Inner Tube Operation, Mechanical Goods Trimming	5	10
Sheet Metal Works		
Miscellaneous Machines, Ordinary Bench Work	4	8
Punches, Presses, Shears, Stamps, Welders, Spinning, Fine Bench Work	6	12
Shoe Manufacturing		
Hand Turning, Miscellaneous Bench and Machine Work	5	10
Inspecting and Sorting Raw Material, Cutting, Stitching, Lasting and Welding	8	16

*Note—The figures under the headings "Class" are foot-candle intensities.

CLASSIFICATION TABLE—Continued

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Soap Manufacturing		
Kettle Houses, Cutting, Soap Chip and Powder	3	6
Stamping, Wrapping and Packing, Filling and Packing Soap Powder	4	8
Steel and Iron Mills, Bar, Sheet and Wire Products		
Soaking Parts and Reheating Furnaces	1	2
Charging and Casting Floors	2	4
Muck and Heavy Rolling, Shearing, rough by gauge, Pickling and Cleaning	3	6
Automatic Machines, Rod, Light and Cold Rolling, Wire Drawing, Shearing, fine by line	4	8
Store and Stock Rooms		
Rough	2	4
Medium	4	8
Fine	5	10
Structural Steel Fabrication	4	8
Textile Mills		
(Cotton)		
Opening and Lapping, Carding, Drawing Frame, Warping, Slashing	3	6
Roving, Spooling, Spinning, Drawing In, Weaving, Dyeing	4	8
(Silk)		
Winding, Throwing, Dyeing	4	8
Quilling, Warping, Weaving and Finishing		
Light Goods	4	8
Dark Goods	6	12

*Note—The figures under the headings "Class" are foot-candle intensities.

CLASSIFICATION TABLE—Continued

Industries Classified on the Basis of Lighting Requirements	For Good Average Lighting*	For Especially Good Lighting*
	Class	Class
Textile Mills (Continued)		
(Woolen)		
Carding	3	6
Picking, Washing and Combing, Twisting and Dyeing	4	8
Drawing in, Warping		
Light Goods	4	8
Dark Goods	6	12
Weaving		
Light Goods	6	12
Dark Goods	8	16
Perching	8	16
Knitting Machines, Cordage Mills	5	10
Tobacco Products	4	8
Toilet and Wash Rooms	2	4
Wood Working		
Rough Sewing and Bench Work	3	6
Sizing, Planing, Rough Sanding, Medium Machine and Bench Work, Glueing, Veneering, Cooperage	4	8
Fine and Bench and Machine Working, Fine Sanding and Finishing	6	12

*Note—The figures under the headings "Class" are foot-candle intensities.

Fig. 8

The Standard RLM Enameled Steel Dome Reflector.

Bowl-frosted MAZDA C lamps, or clear MAZDA C lamps provided with opal caps should be used with these units.

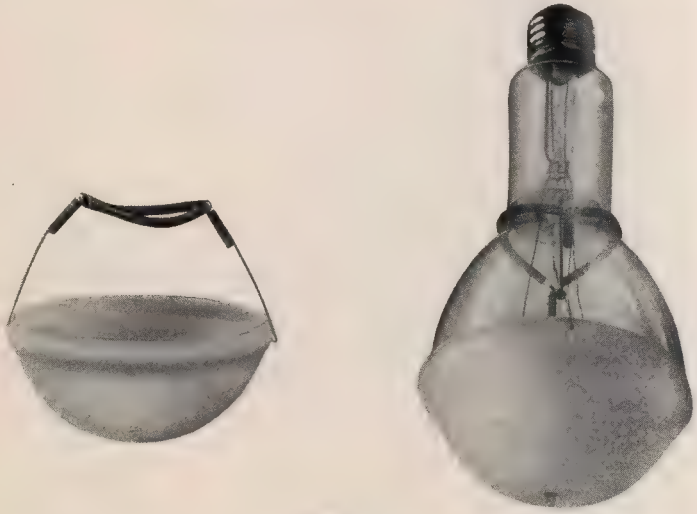


Fig. 9

Opal Lamp Cap for use with clear MAZDA C lamps and RLM Dome Reflectors.

TABLE OF WATTS PER SQUARE FOOT FOR VARIOUS CLASSES OF WORK WHEN ILLUMINATED WITH RLM DOME REFLECTORS AND BOWL-FROSTED MAZDA C LAMPS.

*Class of Illumination as Expressed in Foot-Candles	One Row of Units		More than One Row of Units	
	Light Walls and Ceiling	Dark Walls and Ceiling	Light Walls and Ceiling	Dark Walls and Ceiling
	Watts per per Square Foot	Watts per per Square Foot	Watts per per Square Foot	Watts per per Square Foot
1	.20	.21	.17	.18
2	.39	.42	.31	.34
3	.56	.58	.46	.48
4	.70	.75	.56	.60
5	.87	.91	.70	.73
6	1.00	1.05	.80	.85
8	1.30	1.40	1.05	1.10
10	1.55	1.65	1.25	1.35
12	1.90	2.00	1.50	1.60
16	2.40	2.55	1.90	2.05

*This Table of Watts per Square Foot is based on the illumination requirements as shown in the Classification Tables, pages 21 to 27 inclusive. The number of each class is expressed directly in foot-candles.

For the information of the engineer, it may be stated that the watts per square foot as given in this and following tables have been computed on the basis of the average lumens per watt for the most common sizes of MAZDA C lamps, and the approximate co-efficient of utilization for the conditions assumed. An allowance has also been made to cover depreciation in light output due to dust, etc.

TABLE OF WATTS PER SQUARE FOOT FOR VARIOUS CLASSES ON INDUSTRIES WHEN ILLUMINATED WITH RLM DOME REFLECTORS AND CLEAR MAZDA C LAMPS, EQUIPPED WITH DENSE OPAL CAPS

*Class of Illumination as Expressed in Foot-Candles	One Row of Units		More Than One Row of Units	
	Light Walls and Ceiling	Dark Walls and Ceiling	Light Walls and Ceiling	Dark Walls and Ceiling
	Watts per Square Foot	Watts per Square Foot	Watts per Square Foot	Watts per Square Foot
1	.22	.23	.19	.20
2	.43	.45	.35	.37
3	.60	.63	.49	.53
4	.78	.80	.65	.69
5	.93	.97	.75	.78
6	1.10	1.15	.90	.95
8	1.45	1.50	1.15	1.25
10	1.75	1.80	1.40	1.45
12	2.10	2.20	1.70	1.75
16	2.65	2.80	2.10	2.25

*This Table of Watts per Square Foot is based on the illumination requirements as shown in the Classification Tables, pages 21 to 27 inclusive. The number of each class is expressed directly in foot-candles.

The Ivanhoe Reflecto-cap Diffuser

Fig. 10

Fig. 11

Upper view, Fig. 10, shows unit assembled. Lower view, Fig. 11, shows reflector, holder, lamp and lamp cap

TABLE OF WATTS PER SQUARE FOOT FOR VARIOUS CLASSES OF INDUSTRIES WHEN ILLUMINATED WITH REFLECTO-CAP DIFFUSER UNITS AND CLEAR MAZDA C LAMPS

*Class of Illumination as Expressed in Foot-Candles	One Row of Units		More Than One Row of Units	
	Light Walls and Ceiling	Dark Walls and Ceiling	Light Walls and Ceiling	Dark Walls and Ceiling
	Watts per Square Foot	Watts per Square Foot	Watts per Square Foot	Watts per Square Foot
1	.27	.29	.20	.23
2	.51	.56	.41	.44
3	.75	.82	.62	.66
4	.98	1.05	.79	.84
5	1.20	1.30	.93	1.00
6	1.40	1.50	1.15	1.20
8	1.80	1.95	1.45	1.45
10	2.20	2.45	1.80	1.90
12	2.70	2.85	2.15	2.30
16	3.30	3.60	2.65	2.85

*This Table of Watts per Square Foot is based on the illumination requirements as shown in the Classification Tables, pages 21 to 27 inclusive. The number of each class is expressed directly in foot-candles.

TABLE OF WATTS PER SQUARE FOOT FOR VARIOUS CLASSES OF INDUSTRIES WHEN ILLUMINATED WITH SEMI-ENCLOSING UNITS AND CLEAR MAZDA C LAMPS

	One Row of Units		More Than One Row of Units	
*Class of Illumination as Expressed in Foot-Candles	Light Walls and Ceiling	Dark Walls and Ceiling	Light Walls and Ceiling	Dark Walls and Ceiling
	Watts per Square Foot	Watts per Square Foot	Watts per Square Foot	Watts per Square Foot
1	.29	.33	.21	.25
2	.55	.64	.43	.48
3	.72	.84	.56	.63
4	.94	1.10	.75	.82
5	1.15	1.35	.91	1.00
6	1.35	1.55	1.05	1.15
8	1.75	2.05	1.35	1.50
10	2.15	2.50	1.70	1.85
12	2.50	3.00	1.95	2.20
16	3.30	3.80	2.55	2.85

*This Table of Watts per Square Foot is based on the illumination requirements as shown in the Classification Tables, pages 21 to 27 inclusive. The number of each class is expressed directly in foot-candles.

SEMI-ENCLOSING UNIT

Typical semi-enclosing unit of the one-piece construction class—

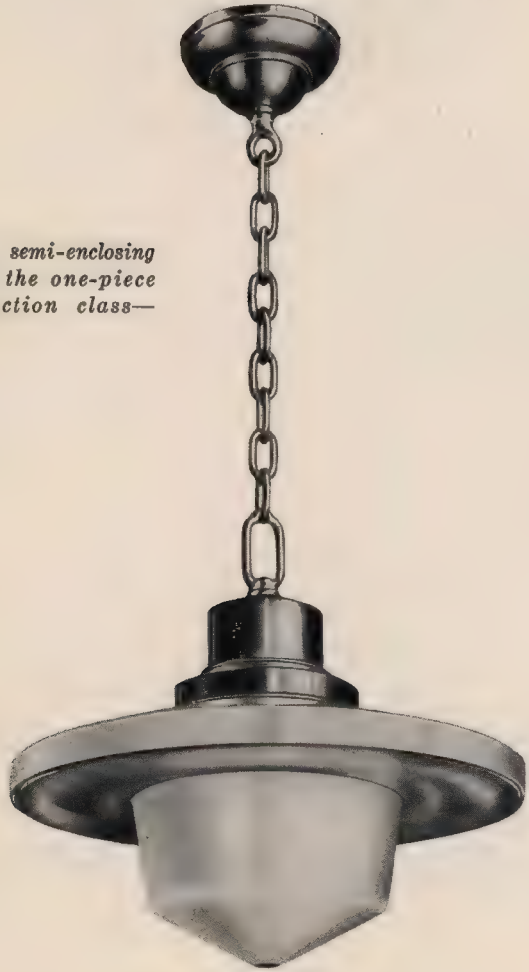


Fig. 12

RLM Standard Dome Reflectors

The permanence of a porcelain-enamel steel surface, even under unfavorable atmospheric conditions, its moderate cost, and the ease with which it can be kept clean, have made it the most generally employed among all industrial reflectors. The RLM Standard Dome, Fig. 8, page 28, has been specially designed by the principal manufacturers of metal reflectors and the illuminating engineers of the MAZDA lamp manufacturers to employ the light of MAZDA C lamps most effectively.

In order to conform to the RLM Standard specifications, reflectors must have a surface of good quality and high reflecting power, the proper angle of cut-off, and diameter, and a contour such as to distribute the light most efficiently.

Bowl-Frosted Lamps

Clear bulb MAZDA C lamps, except with opal caps, should not be used with dome reflectors at mounting heights of less than 20 feet. At this height the nearest lamp within the usual field of vision is so far removed that ordinarily the amount of light entering the eye directly from it is insufficient to cause glare; also the lighting unit subtends so small an angle at the working surface that shadows are not greatly softened by frosting the lamp. When suspended at a height of 20 feet or less from the floor the lamps should be bowl-frosted or otherwise rendered diffusing. Contrary to a rather common impression the bowl-frosting of lamps does not affect their life and when used with RLM Dome Reflectors does not increase the loss of light from absorption by more than 3 or 4%.

Opal Caps

So far as direct glare from the units themselves is concerned, bowl-frosting the lamps would usually prove sufficient. However, in some cases, the resulting brightness of images of the unit in polished working surfaces may be found excessive, and shadows remain so sharp as to be annoying, inasmuch as nearly one half of the light received at the work comes directly from the small surfaces of the lamp itself. Where the more exacting visual requirements exist, it is well to fit the lamps with the dense opal diffusing cap shown in Figure 9, page 28. When this is done, glare, both from the lamp itself and from specular images, will be almost entirely eliminated. The output of the unit will be decreased, but most of the light will come from the large surface of the reflector and therefore shadows will be made soft and luminous with gradually fading edges. The work of maintenance is somewhat increased when these caps are employed, inasmuch as a small amount of dust will enter the narrow space sometimes left between the cap and the lamp bulb. The glass itself, however, is smooth and may be readily cleaned.

Reflecto-cap Diffuser Unit

The Reflecto-cap Diffuser, as shown in Figures 10 and 11, page 31, is recommended for installations requiring high intensity, but where glare is likely to occur and where it is especially objectionable. This unit may be properly installed for the lighting of high grade machine shops, plate glass work, inspection processes or in other places where there may be reflections from polished or oily surfaces.

With this unit, direct glare is avoided by covering the lower part of the bulb of the MAZDA C lamp with a silver plated cap, Figure 11, page 31. This cap hides the filament from the eye, and directs the rays of light to the large reflector above.

The light is distributed evenly over the entire surface of the reflector, so that it is possible to view the unit from any direction without discomfort to the eyes; and the size and shape of the reflector have been scientifically determined to give a thorough diffusion of light, thus avoiding reflected glare from polished or smooth objects in the working plane.

Semi-Enclosing Units

Because of the pleasing effect of well illuminated ceilings and walls, semi-enclosing fixtures are often used instead of porcelain-enameled reflectors in industrial plants. These fixtures consist of a diffusing glass bowl suspended beneath the lamp, above which is placed either an opaque reflector or one of dense opal glass. This upper reflecting surface is usually made large in order to produce added diffusion. The space between the lower bowl and upper reflector is sometimes left open, or it may be enclosed with clear glass. Again, the unit may be in one piece with a coating of enamel placed on the outside of the upper reflector and of the lower bowl. To be most satisfactory, fixtures of this type should have a fairly large bowl of considerable density so that the brightness may not be excessive. Those units with the greatest number of vital surfaces exposed to dust accumulation will, of course, show the most rapid depreciation in service. If, as in the case of the fixture shown in Figure 12, page 34, dust accumulation can be confined practically to the upper surface, loss from this cause will be small.

The first cost of semi-enclosing fixtures is, of course, considerably greater than that of a dome reflector with opal cap. However, the appearance of an interior is frequently enhanced by their use and the condition therefore made conducive to better work. The cost of maintaining such equipment would be excessive in locations where the units are likely to be struck by belts or materials. However, the danger of breakage is often overestimated; there are many manufacturing spaces where they may be applied with little difficulty.